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(Research Article)

Estimation of Environmental Impact from Rice Mill Cluster

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Abstract

The developed and developing countries in the world currently facing many challenges put forth by rapid growing population and in satisfying its needs. Though technology is progressing in hand with evolving industrial requirements, still industries are failing in conserving the biosphere. Globally the India has stood fourth in GHG emissions with 1725.76 million metric tons, 1.45 per capita CO_2 emissions during year 2011. In India electricity generation, Manufacturing and construction, transportation and agriculture are the major sectors, which contribute for the net annual GHG emissions. Approaching towards food processing industries, the rice mills are found to have appreciable share in Industrial GHG emissions inventory. Present work gives the estimation of GHG emissions from chosen 40 rice mills of Koppal cluster per standard working month. The energy consumption data is collected through questionnaire based survey. The GHG emissions estimation is made using tier 1 and tier 2 approaches as per revised 1994 IPCC guidelines.

Keywords: Global warming potential, Green House Gases, types of Pollution, Rice mills, Estimation of GHG emissions.

1. Introduction

The phenomenon of warming up of the atmospheric temperature in relation to solar radiation is termed as Green House effect. In this incident, some portion of heat from solar radiation is retained in atmosphere by Green House Gases (GHG), which absorbs a portion of heat from sun light and reflects back to the earth's surface thereby increasing the atmospheric temperature. For estimating this amount of heat trapped by GHG the Global Warming Potential (GWP) is used [1], which compares the heat absorbed by a gas of certain mass in relation to that of Carbon dioxide (CO_2). GWP is conveyed as a factor of CO_2 and it is normally evaluated for a specific period of 20, 100 or 500 years.

Green House Gases mainly comprises Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), Ozone, Chlorofluoro carbons-11 (CFC-11), Hydrofluoro carbons-23 (HFC-23) and Perfluoro carbons (CF_4). In addition to these gases, GHG also contains other gases in smaller proportions. The industrial activities [2], energy production sector, Airways, Domestic appliances like refrigerators, Air Conditioners are the major contributors for the GHG emission Inventory. The fossil fuel burning claims as chief cause with 75% GHG emissions. As the GHG emission increases the Green House effect increases, consequently the air pollution due to accumulated poisonous gases in the atmosphere causes harmful effects on the human health and ecology.

Globally the GHG emissions gradually increased in the course of past 30 decades due to boom of industries [3], vehicles, and food requirements in quantity. Increased population and its demands can be indicated as one of the core sources for the augmentation of global warming effect. Globally the awareness regarding harmful effects of pollution through industries and Green House effect endured through 1960's. In the world, the governmental and non-governmental organizations, which strived for reduction of GHG emissions are UNEP (United Nations Environment Programme), UNFCC (United Nations Framework Convention on Climate Change), IPCC (Intergovernmental Panel on Climate Change), European Union's Restriction of the Use of Certain Hazardous Substances in Electric and electronic equipment (RoHS in EEE), Waste Electronics and Electrical Equipment (WEEE), Montreal Convention and Kyoto Protocol.

India, which is a developing nation, stood fourth in GHG emissions across the world with the share of 6% [4]. India has accounted for the GHG emissions of about 2.3 $GtCO_2$ during the year 2014. Using the guidelines of UNEP, UNFCC and IPCC in India the centre has took well organized planning in mitigating the GHG emissions below 2700 million metric tons by the year 2030 and furthermore it has stipulated certain norms, rules and regulations to be executed through Central Pollution Control Board and State Pollution Control Boards. According to IPCC, during the year 2014 the major sectors around the globe which contributed for GHG emissions

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include industry-21%, transport-14%, electricity generation-25%, building-6%, agriculture and forestry-24% and other energy-10%.

In the agriculture, rice industry holds a prominent share in terms of energy use. Rice is the major food grain across the world, consumed by 60%-65% of the population. Globally, it is estimated that about more than 3500 million people eat rice as their vital food. Likewise, in India especially middle and southern part of it, rice consumption is found to be high [5]. India is the second largest producer of rice in the world with annual turnover of 155.68 Million Tons (MT) during 2015. In India, West Bengal is the leading rice producing state with a turnover of 150.24 Lakh Tonnes (LT) during 2012-2013, whereas Karnataka stands tenth in rice production with turnover of 32.8 LT during 2012-2013.

Coming towards Agro and food processing industries in India, rice mills can be chosen as significant industry, which contributes for Nations GHG emissions inventory. It is assessed that there are more than 6000 major rice mills in India. In the Karnataka state there are about 3674 mills including major rice mills and the rice mills, which fall under MSMEs (Micro Small and Medium Enterprises). The GHG emissions in rice mill industry is due to use of Boiler for parboiling process, generator for alternative power supply at the time of grid power cut and in minor due to electricity utilization [6]. There are four types of pollution through rice mills such as Air pollution, Land pollution, Water pollution, and Sound pollution. Out of these four modes, effect of air pollution is more significant. Therefore, the impact on environment due to air pollution (i.e. GHG emissions) through Koppal rice mill cluster is chosen for the study. The subsequent sections provide the details of sources of GHG emissions, estimation of GHG emissions in the rice mill cluster and the possible solutions for reducing this GHG emission.

2. Estimation of GHG Emissions

In Koppal rice mill cluster, a sample of 40 rice mills are chosen for the study. For estimating the GHG emissions, the monthly energy consumption data for each unit is collected. UNEP and IPCC guidelines are employed in finding the net GHG emissions from each unit.

2.1 Sources of GHG emissions: In Karnataka state about 35% - 40% of rice production includes parboiled rice, which calls for utilization of boiler for parboiling process. In boiler, mostly rice husk is used as fuel, which is the byproduct of rice processing [7]. It is estimated that for processing one ton of paddy, parboiling process requires 200 Kg of steam. This rice husk combustion in boiler emits GHG such as Carbon dioxide, Methane, Nitrous oxide, Carbon monoxide, Nitrogen oxides, Non Methane Volatile Organic Compound and Sulphur dioxide.

Utilization of diesel in generators emits GHG's such as Carbon dioxide, Methane, Nitrous oxide, Carbon monoxide, Nitrogen oxides, Non-Methane Volatile Organic Compound, Sulphur dioxide, Black Carbon, Ammonia and Particulate matter of 10 microns.

For electricity consumption in Rice mills, the CO_2 equivalent in kg/month is utilized which is available for the national level.

2.2 Procedure followed for estimation of GHG emissions: GHG emissions from rice mills is possible through three main sources and are estimated as given below:

2.2.1 Estimation of CO_2 equivalent of electricity in kg/month: The monthly data of electricity usage from 40 rice mills is gathered in terms of number of kilo watt-hours (kwh). In addition, this variable is multiplied by the emission factor (0.00089 tCO_2/kWh) as stipulated in UNEP guidelines 1996 for India [8].

2.2.2 *GHG emissions through combustion of rice husk in boiler:* The monthly consumption data of rice husk fuel in boiler for parboiling process according to the firm capacity is obtained in terms of number of tons of husk. Subsequently, it is converted to the number of Tera joules of consumption per month with the regional calorific value (3465 Kcal/kg) of husk. The resulting vale is multiplied with the emission factors of each required GHG as stipulated in Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual.

The GHG emissions from rice husk combustion includes Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), Nitrogen oxides (NO_x), Carbon monoxide (CO), and Non-Methane Volatile Organic Compound (NMVOC) are estimated using IPCC Tier 1 Approach formula as given below:

$$Emissions = \sum (EF_{ab} \times Activity_{ab}) \tag{1}$$

Where
EF= Emission Factor (kg/Tj)
Activity= Energy input (Tj)
a= fuel type
b= Sector-activity

2.2.3 *GHG emissions through combustion of diesel in generator:* The monthly consumption of diesel fuel in Generator (litres of diesel) based on number of hours of operation per day and daily diesel is computed. Then, it is converted to the number of Kilograms of Diesel consumption per month using its regional diesel specific gravity or density. This data is again converted into number terajoules of consumption per month using regional diesel specifications or its calorific value. The resulting value is multiplied with the emission factors of each required GHG as stipulated in Revised 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories: Reference Manual [9].

The GHG emissions from diesel fuel combustion includes Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), Nitrogen oxides (NO_x), Carbon monoxide (CO), Non-methane volatile organic compound (NMVOC), Ammonia (NH3), Black carbon (BC), and Particulate matter$_{10}$ (PM_{10} - means 10 micrometers or less in diameter) are found out using IPCC Tier 1 Approach formula as given below [10]:

$$Emissions = \sum (EF_{ab} \times Activity_{ab}) \quad (2)$$

Where
EF= Emission Factor (kg/Tj)
Activity= Energy input (Tj)
a= fuel type
b= Sector-activity

In both the cases of GHG emissions, Sulphur dioxide (SO_2) gas emission is estimated using the formula-

$$EF_{(SO_2)}[kg/Tj] = 2 \times \left(\frac{S}{100}\right) \times \frac{1}{100} \times 10^6 \times \left(\frac{100-r}{100}\right) \times \left(\frac{100-n}{100}\right) \quad (3)$$

Where
EF= Emission Factor [kg/Tj]
2= SO_2/S [kg/kg]
S= Sulphur Content in fuel [%]
R= Retention of Sulphur in ash [%]
Q= Net Calorific value [Tj/kt]
10^6= (unit) conversion value [Tj/kt]
n= Efficiency of abatement technology and or reduction efficiency [%]

The emission factor of Sulphur dioxide for rice husk is 2.389 obtained by taking sulphur content in rice husk as 0.03, net calorific value as 12.56 Tj/kt, and reduction efficiency as 95%. The emission factor of Sulphur dioxide for diesel fuel is 80.3786 obtained by taking sulphur content (S) as 0.8, net calorific value as 44.79 Tj/kt, reduction efficiency as 90%. Retention of sulphur in ash is neglected in both the cases [11].

3. GHG Emission Estimation Results

The table 1 gives the summary of monthly GHG emissions due to electricity utilization, rice husk combustion, diesel fuel consumption from the sample of 40 Rice mills of Koppal cluster.

Table 1. Summary of GHG emissions from 40 rice mills of Koppal cluster

	CO_2 equivalent to electricity(tCO_2/Kwh)in Kgs	GHG emissions due to rice husk in Kgs	GHG emissions due to diesel in Kgs	Total emission in Kgs
CO_2 emissions in kgs/month	1756.37	776134.44	48114.33	1259035.14
CH_4 emissions in kgs/month		232.84	19.48	252.32
N_2O emissions in kgs/month		31.05	3.90	34.94
NO_x emissions in kgs/month		776.13	1298.64	2074.77
CO emissions in kgs/month		31245.38	64.93	31110.31
NMVOC emissions in kgs/month		388.07	32.47	420.53
SO_2 emissions in kgs/month		18.54	521.91	540.45
NH_3 emissions in kgs/month			0.05	0.05
BC emissions in kgs/month			23.32	23.32
PM_{10} emissions in kgs/month			21.43	21.43

- From the Table 1, CO2 equivalent emission from electricity consumption is about 1756.37 kg/month.
- Carbon dioxide has the major share of emission in case of rice husk and diesel combustion. The net total emission of CO2 is 1259035.14 kg/month.
- Total emissions of other GHG's are Methane: 252.32 kg/month, Nitrous oxide: 34.94 kg/month, Nitrogen oxides: 2094.77 kg/month, Carbon monoxide: 31110.31 kg/month, NMVOC: 420.53 kg/month, Sulphur dioxide: 540.45 kg/month, Ammonia: 0.05 kg/month, Black carbon: 25.32 kg/month and Particulate matter10: 21.43 Kg/month.
- From the above table, the gases CO2, CO, CH4 and SO2 were found to have adverse effects on the human health.

The figure 1, provides the comparison of GHG emission from the three sources viz., electricity utilization, rice husk and diesel. The GHG emissions due to rice husk combustion is found to be high than that of diesel combustion in generators.

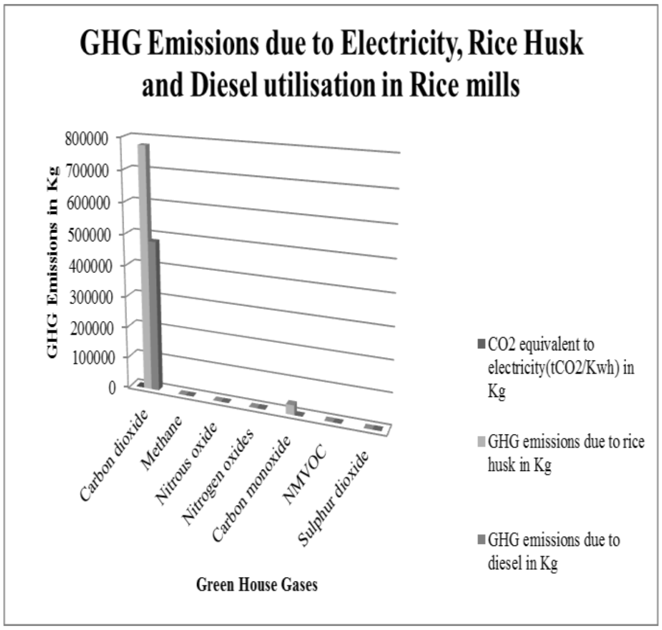

Figure 1. Comparison of GHG emissions from the three sources

The figure 2 gives the graphical representation of GHG emissions of 40 rice mills. Figure 2 provides net monthly emission of each GHG from the sample 40 rice mills of Koppal cluster.

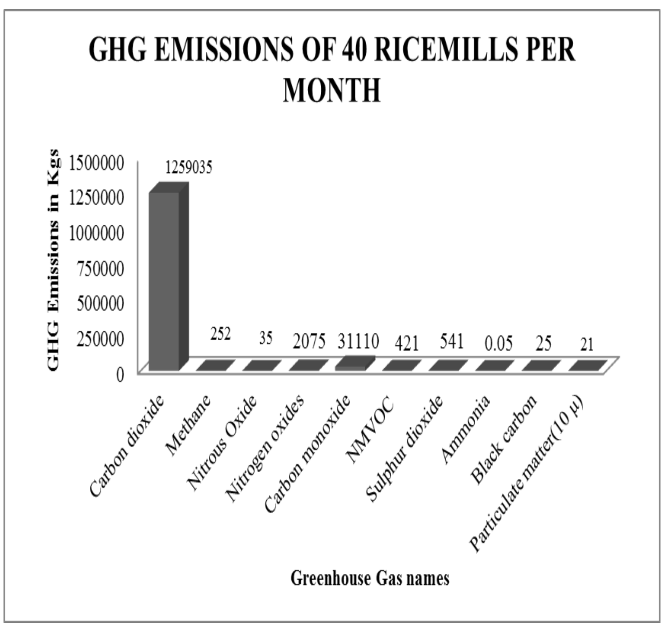

Figure 2. GHG emissions through 40 Rice mills per month

3.1 *Possible solutions for reducing GHG emissions:* The following suggestions are made to rice mills for reducing GHG emissions:

- Utilization of latest devices such as bag filters in the chimney passage.
- Replacement of the Old aged boilers with that of modern Veeson's boiler or Mirco Dynamics boiler or Thermax boilers, because they consumes less amount of husk per day leading to reduced GHG emissions.
- Improving the skills of workers by means of training and education. This creats proper awareness regarding environmental pollution and its harmful effects.
- Harnessing renewable energy sources like Solar and Wind energy to the extent possible, this is less in cost and eco-friendly in nature.
- Efficient use of energy resources by following cleaner production practices.

4. Conclusions

The primary purpose of this paper is to study and estimate the environmental impact caused by a rice mill cluster. The objective is to create awareness among large scale and MSMEs management about the causes and consequences of different varieties of pollution. The quantum of GHG emission is estimated apart from suggesting ways and means of mitigating it.

In the chosen sample of Koppal rice mill cluster, the annual GHG emissions estimated is approximately 7.55 $ktCO_2$.The probable causes for GHG emissions are due to excess use of energy resources than needed, lack of proper maintenance of firm machinery, employment of low skilled workers and lack of implementing advanced energy efficient technology. Application of Renewable energy sources such as solar energy, wind energy must also be explored to reduce GHG emissions. It may be advocated that rice mills must accord top most importance for energy efficiency enhancement because it can result in twin benefits of cost reduction due to reduced energy use and also reduced environmental pollution and GHG emission. This will go a long way in the sustainable growth of this rice mill cluster in the long run.

Nomenclature

IPCC: Intergovernmental Panel for Climate Change.
UNEP: United Nations Environmental Programme
UNFCC: United Nations Framework Convention on Climate Change
GWP: Global Warming Potential
NMVOC: Non methane Volatile Organic Compound
PM: Particulate matter
BC: Black Carbon
Gt: Giga tons
Kt: Kilo tons

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